INDOOR AIR QUALITY ASSESSMENT

McKay Elementary School
McKay Street
Beverly, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment
Emergency Response/Indoor Air Quality Program
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Background/Introduction

At the request of a parent, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA) was asked to provide assistance and consultation regarding indoor air quality concerns at the McKay Elementary School (MS), Beverly, MA. Mr. William Burke of the Beverly Health Department recommended the services of the MDPH. Students and faculty from the Centerville Elementary School are currently housed at the MS school while the Centerville school is under renovation. The MS was converted to “swing space” for various school renovation projects in Beverly. School Officials reported that this is the final year for occupation of the McKay as an Elementary School. Concerns regarding the hospitalization of a student with pulmonary problems attending this school, and the potential connection with indoor air quality prompted the inspection. Subsequent to this request the Beverly School Department also asked BEHA for technical assistance.

BEHA staff were specifically requested to examine classrooms for sources of microbial (mold) growth and other potential factors that could adversely affect indoor air quality. Previous mold testing as well as testing to be scheduled, were briefly discussed in a previous letter to the Beverly School Department (MDPH, 2003) (see Appendix I). This report describes the results of mold testing in more detail as well as general indoor air quality conditions observed during recent BEHA site visits.

Cory Holmes, an Environmental Analyst in BEHA’s Emergency Response/Indoor Air Quality (ER/IAQ) program, originally visited the McKay school in December of 1998. A report was issuedØdescribing the conditions of the building, which was under renovation, and gave recommendations concerning remediation of some conditions noted in the building (MDPH, 1999). The 1999 BEHA report is attached as Appendix II. After receiving a call from a parent and at the direction of BEHA management Mr. Holmes returned to the building on December 31, 2002 accompanied by Mr. Burke, Ron Bouchard, Director of Buildings and grounds and other members of the Beverly School Department Maintenance staff. At that time Mr. Holmes recommended that the band room should no longer be used based upon the strong mold like odors noted during the visit. The building was further examined on January 7, 2003 by Suzanne Condon, Assistant Commissioner, BEHA; Mike Feeney, Director of BEHA's ER/IAQ Program and Mr. Holmes. Mr. Holmes returned for a follow up visit on January 9, 2003 to examine rooftop conditions including rooftop ventilation components.

The Beverly School Department and concerned parents provided BEHA staff with copies of reports, letters and memorandum related to the IAQ problems at the MS. From these reports, the MS appears to have a history of indoor air quality concerns and attempts by school officials to address those concerns. As reported by school officials and parents, the building experienced water damage in the basement due to flooding/backflow from a floor drain approximately 3-4 years ago. As a result the floor drain was reportedly sealed and sections of water damaged gypsum wallboard (GW) were replaced. In 2001 an indoor air quality study was conducted to assess the MES by a consultant, Friend Laboratory Incorporated (FLI). Testing of various indoor air quality parameters (i.e. carbon dioxide, carbon monoxide, temperature, relative humidity, total volatile organic compounds and bioaerosol sampling for airborne microbials) were conducted (FLI, 2001). The FLI report recommended:

- The increase of outside air on a continuous basis to reduce carbon dioxide levels, with consideration of taking measures to introduce additional supply ventilation;
- That floors, walls, and shelves be thoroughly disinfected; and

- That material safety data sheets (MSDS) for all cleaning products and chemicals used in the school are maintained in a central location (FLI, 2001). The FLI report is attached as Appendix III.

New carpeting was reportedly installed in basement classrooms 2-O and 2-M in July of 2002. According to school department officials, an occupant noted staining, which may or may have not been mold growth, on the replaced GW section between these two classrooms. As a precaution, an approximate 3' x 6' section of GW was replaced in late October 2002.

In November of 2002, after remediation of the GW between rooms 2-O and 2-M, a second consultant, ATC Associates Inc. (ATC) was hired. This consultant performed airborne sampling for microbial analysis and took carpet dust samples for fungi and bacteria. The ATC report is attached as Appendix IV. Carpet samples taken by ATC found fungal and bacterial contamination in carpet samples. Based on their findings the ATC report recommended:

- The operation of classroom unit ventilators (univents) to provide continuous airflow; and
- Carpeting in all rooms evaluated be cleaned using high temperature "dry" steam and a high efficiency particulate arrestance (HEPA) filtered vacuum cleaner (ATC, 2002). Carpets throughout the school were steam cleaned the weekend of Dec 23, 2002.

Most recently, a third consultant, Gordon Mycology (Gordon) was hired to conduct microbiological testing for airborne, carpet and wipe samples. This testing occurred after school hours on the evening of January 6, 2003. The testing conducted by Gordon found no airborne levels of mold in any at the interior occupied spaces. They did measure some levels in the band room, however as previously discussed this room is currently unoccupied, which would limit exposure to building occupants. With respect to dust and bulk samples of walls and carpets some microbial growth was measured, however, based on the nature and amount, they do not presently exceed levels of health concerns. This opinion is further explained in Appendix V, in a letter from Dr. Michael Muilenberg of the Harvard School of Public Health.

Methods

BEHA staff performed, visual inspection of building materials for water damage and/or microbial growth. On December 31, 2002, water content of gypsum wallboard (GW) was measured with a Delmhorst, BD-2000 Model, Moisture Detector with a Delmhorst Standard Probe. Air tests for carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551. Results of testing for microbiological contamination conducted by Gordon Mycology were reviewed in collaboration with Dr. Muilenberg.

Results

The MS currently houses Centerville School students in grades K-5. It has a student population of approximately 340 and a staff of approximately 40. Testing on December 31, 2002 occurred while the building was unoccupied. Tests taken on January 7, 2003 were taken under normal operating conditions. Test results appear in Tables 1-4.

Discussion

It can be seen from the tables that carbon dioxide levels measured on January 7, 2003 were elevated above 800 parts per million of air (ppm) in all occupied areas surveyed, indicating inadequate ventilation in the building. It is important to note, that some classrooms had open windows during the assessment, which can greatly reduce carbon dioxide levels, further indicating a lack of air exchange. Carbon dioxide levels measured on December 31, 2002 were below 800 ppm, however these measurements were taken while the school was *unoccupied* and do not reflect normal conditions.

Ventilation on the first and second floors of the school was originally provided to classrooms by a natural gravity ventilation system, which distributed rising heated air called the stack effect. This system is described in detail in BEHA's 1999 report. School department officials reported that this system has been deactivated; therefore opening windows is the sole source of providing fresh air in first and second floor classrooms at present.

Classrooms in the basement floor were created from a large space that was formerly the school cafeteria. Basement classrooms 2-O and 2-M have been retrofitted with a unit ventilator (univent) system (see Picture 1). Univents draw air from outdoors through a fresh air intake located on the exterior walls of the building (see Picture 2) and return air through an air intake located at the base of each unit. Fresh and return air are mixed, filtered, heated and provided to classrooms through a fresh air diffuser located in the top of the unit (see Figure 1). Mechanical exhaust ventilation is provided by motorized wall vents, which operate continuously (see Picture 3).

At the time of the assessment, neither of the univents were being operated continuously. Univents are controlled by thermostats that have fan settings of "on" and "automatic". In the automatic setting, univents are activated by thermostats once room temperatures drop below a set level. When the room temperature exceeds the thermostat setting, univents deactivate. Without mechanical ventilation running continuously, fresh air cannot be introduced into classrooms on a consistent basis. The operation of the univents appears to be independent of the exhaust vents within each classroom. When the univents were deactivated, the exhaust vents were drawing air from classrooms. The continuous operation of the exhaust vents combined with the intermittent operation of univents can depressurize the basement classrooms. Once depressurized the negative airflow in basement classrooms can draw odors, particulates and other airborne materials from wall cavities, utility holes and other parts of the building. Irritant and other comfort symptoms, (e.g. headaches), would not be unexpected under these conditions.

During the January 7, 2003 visit BEHA recommended operating the univents in the fan "on" mode to provide a continuous source of fresh air and to balance pressure appropriately. During the January 9, 2003 visit, BEHA staff noted that both the exhaust vents and univents were operating continuously.

Other occupied spaces in the basement do not appear to have direct ducted sources of fresh air supply. The adjustment counselor's office is not equipped with mechanical ventilation, but has passive vents installed in the doors designed to draw air from the hallway. Two local exhaust fans were installed in an interior wall to provide air exchange, however these fans were not in operation during any of the BEHA visits. Without exhaust ventilation, indoor air pollutants can build up and lead to indoor air quality/comfort complaints. The speech/pathology room has no means of mechanical ventilation or openable windows.

In order to have proper ventilation with a mechanical supply and exhaust system, these systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. According to school department officials, the date of the last balancing of these systems was not available at the time of the assessment. It is recommended that existing ventilation systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994).

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week based on a time weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, please see Appendix VI.

Temperature readings were measured in a range of 66^{o} F to 69^{o} F, during the December 31, 2002 visit, which were below the BEHA comfort guidelines, however, as previously mentioned, the building was unoccupied. During the January 7, 2003 visit, temperature readings were measured in a range of 69° F to 73 ° F, which were very close to the BEHA comfort guidelines. The BEHA recommends that indoor air temperatures be maintained in a range between 70 ° F to 78 ° F in order to provide for the comfort of building occupants. A number of temperature control/comfort complaints were expressed by occupants throughout the building. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply. It is often difficult to control temperature and maintain comfort without operating the ventilation equipment as designed (i.e. the building's original ventilation system has been abandoned). The original fresh air supply system, as described in the previous BEHA report, pressurized each classroom by the flow of heated air from supply ducts. This pressurization is now absent due to the abandonment of this system. Drafts were noted by BEHA staff from abandoned exhaust vents in first and second floor classrooms (see Pictures 4 & 5). These vents are connected to airshafts that terminate from (three) chimney-like structures on the roof. The chimneys are capped by louvered vents equipped with bird screens (see Picture 6). However, because the system has no mechanical fans system, cold air can sink down the airshafts, creating air back flowing, which generates cold air drafts from exhaust vents.

The relative humidity in this building ranged from 27 to 32 percent during the December 31, 2002 visit and from 23 to 34 percent during the January 7, 2003 visit, both of which were below the BEHA recommended comfort range. The BEHA recommends that indoor air relative humidity is comfortable in a range of 40 to 60 percent. Relative humidity in this building would be expected to drop below comfort levels during the heating season. The sensation of dryness and irritation is common in a low relative humidity environment Relative humidity levels in the building would be expected to drop during the winter months due to heating. It is important to note however, that relative humidity measured indoors exceeded outdoor measurements during air testing conducted when the building was occupied on January 7, 2003 (range +2 to +16 percent).

Air monitoring conducted on December 31, 2002, showed relative humidity levels *below* outdoor measurements (range –13 to -18 percent). The increase in relative humidity during occupancy indicates that a contributing source of water vapor in this building is the occupants. Relative humidity measurements would be lower if the building had an adequate operation mechanical ventilation system that could dilute and remove normal indoor air pollutants (e.g., water vapor from respiration).

Moisture removal is important since the sensation of heat conditions increases as relative humidity increases (the relationship between temperature and relative humidity is called the heat index). As indoor temperature rises, the addition of more relative humidity will make occupants feel hotter. If moisture is removed, the comfort of the individuals is increased. Removal of moisture from the air, however, can have some negative effects. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

In order for building materials to support mold growth, a source of water is necessary. Identification and elimination of water moistening building materials is necessary to control mold growth. GW with increased moisture content over normal concentrations may indicate the possible presence of mold growth. Identification of the location of GW with increased moisture levels can also provide clues concerning the source of water supporting mold growth. In an effort to ascertain moisture content of GW, samples were taken in areas most likely impacted by water damage, primarily the dividing wall between basement classrooms 2-O and 2-M (see Picture 7), as well as a number of non-effected areas for comparison. The moisture meter probe was inserted into the surface of GW on walls. The Delmhorst probe is equipped with three lights as visual aids to determine moisture level. Readings, which activate the green light, indicate a sufficiently dry level (0 - 0.5%), those that activate the yellow light indicate borderline conditions (0.5 – 1.0%) and those that activate the red light indicate elevated moisture content (> 1%).

A number of moisture measurements were taken of GW at varying heights (i.e. three feet, two feet, and six inches above the floor respectively). No elevated moisture measurements were recorded. Visual inspection of classrooms 2-O & 2-M suggested no obvious water damage on walls, ceilings or carpeting. These results indicate that the GW is not moistened at the time of this assessment and that further microbial growth would be limited due to a lack of water.

It was reported that new carpeting was installed in basement classrooms 2-O and 2-M in July of 2002. During the spring and summer of 2002, New England experienced a stretch of excessively humid weather during three periods in May, July and August. As an example, outdoor relative humidity at various times from 73 percent to 100 percent without precipitation from July 4, 2002 through July 12, 2002 (The Weather Underground, 2002). Building staff reported that the ventilation system had been deactivated over the summer. Without dilution and removal created by the mechanical ventilation system, excess heat and moisture can build up inside the building. The accumulation of moist air can lead to condensation on floor surfaces becoming “trapped” beneath carpeting or within GW wall cavities, which may leading to microbial growth. Carpeting is a porous material and can provide a source of microbial growth especially if wetted repeatedly.

Other potential sources of microbial growth and associated odors were also observed. Musty, mold-like odors were detected in the band room. The band room had several dehumidifiers that had reportedly not been in use since autumn, containing standing water (see Picture 8). Water damaged ceiling tiles were also observed, near plumbing fixtures which can indicate current or historic leaks from the plumbing system. Water-damaged ceiling tiles can provide a source of mold and should be replaced after a water leak is discovered.

The band room has wall paneling installed along exterior foundation walls. Masonry around windows appeared to be eroded from significant water damage. In general wall paneling installed in this manner may conceal and contain moisture from water penetration through the foundation wall or condensation on the cement. In either case, the paneling can serve to prevent the evaporation of moisture from this area, and can result in repeated moistening of wall paneling and wall-to-wall carpet. Wall materials, such as paneling, can serve as a mold growth medium. In addition signs or water penetration through foundation walls as evidenced by the presence of peeling paint and efflorescence along exterior walls in areas with exposed, painted foundation wall brick. Efflorescence is a characteristic sign of water damage to brick and mortar, but it is not mold growth. As moisture penetrates and works its way through mortar around brick, water-soluble compounds in bricks and mortar dissolve, creating a solution. As the solution moves to the surface of the brick or mortar, the water evaporates, leaving behind white, powdery mineral deposits. A coat of paint can serve as a water impermeable barrier, which can collect moisture and efflorescence. Brick, mortar and wall plaster is not a good mold growth media, however water trapped behind wallpaper or paint coats can become mold growth media.

Different means for water to have prolonged contact with the foundation wall exist around the perimeter of the building. Small trees and other plants were also seen growing in the tarmac/exterior wall junction (see Picture 13). The growth of roots against the exterior of foundation walls, as well as spaces between the tarmac, can bring moisture in contact with brick and foundation structures, which may eventually lead to moisture penetration below ground level areas of the building. Over time, this process can undermine the integrity of the building envelope and provide a means of water entry into the building through capillary action through foundation concrete and masonry (Lstiburek, J. & Brennan, T.; 2001). Once through the foundation wall, the installation of paneling serves to prevent moisture evaporation, potentially moistening of wall materials and wall to wall carpet.

A number of means exist for uncontrolled airborne moisture and rainwater to penetrate into the basement. Spaces around exterior doors were observed in several areas in the basement (see Pictures 9). Spaces around exterior doors can allow a means of water penetration into the building, subsequently wetting building materials. The wooden doors themselves showed signs of repeated water damage (see Picture 10). In some cases carpeting is installed directly inside these areas (see Picture 10). Carpeting in the band room had a number of water stains that indicated previous water damage.

Several classrooms contained a number of plants. Plant soil and drip pans can serve as a source of mold growth. Plants and potting soil were found on top of univents in several classrooms. Some plants were noted in standing water (see Picture 11). Plants should be properly maintained and be equipped with drip pans. Plants should also be located away from air diffusers to prevent aerosolization of dirt, pollen or mold. Picture 12 shows a classroom aquarium that was green with microbial growth. Aquariums should be properly maintained as to not grow mold and or provide a source of unpleasant odors.

The American Conference of Governmental Industrial Hygienists (ACGIH) recommends that porous materials (e.g. GW and carpeting) be dried with fans and heating within 24 hours of becoming wet (ACGIH, 1989). If porous materials are not dried within this time frame, mold growth may occur. Once mold growth has occurred, disinfection of these materials may be possible, however since GW is a porous surface, disinfection is likely to be ineffective.

On previous assessments concerning GW mold growth, BEHA personnel have consulted with Dr. Harriet Burge, Chairperson of the Microbiology Department at the Harvard School of Public Health. The reoccurrence of mold growth on GW after the application of bleach is common. Bleach consists of sodium hypochlorite in a 5 percent concentration mixed with water. Mold colonization of GW can penetrate through its entire structure. When applied to moldy GW, the water of the bleach solution penetrates into the moldy GW, but the sodium hypochlorite remains on the surface. The sodium hypochlorite disinfects the surface mold that it comes in contact with on the GW surface, but not the mold beneath the surface. The additional water added to the subsurface mold fuels a spurt in growth, which increases mold colonization of the GW. As a result, mold colonies appear on the surface of treated GW shortly after application of bleach (personal communication, Burge, 1999). If GW is treated with bleach, the configuration of interior walls in the basement would tend to prevent drying within the wall cavities. Several areas observed by BEHA staff found fiberglass insulation installed inside the wall cavity of interior basement walls. The purpose of this insulation would be to limit the transmission of sound between classrooms. One function of insulation is to limit airflow between space to prevent heat loss. This prevention of airflow also prevents drying of the wall cavity surface of

GW, which can keep these materials moistened for extended periods of time. In addition, insulation can also absorb and hold moisture, which can then serve as a moisture reservoir that can continue to keep GW moistened. Please note that the US EPA recommends that GW "[m]ay be dried in place if there is no obvious swelling and the seams are intact. If not, remove, discard, and replace. Ventilate the wall cavity, if possible." (US EPA, 2001). The installation of insulation would prevent such drying and may lead to mold colonization. For these reasons it was important to determine the mold content of bulk wall samples in the building.

Other Concerns

Several other conditions were noted during the assessment, which can affect indoor air quality. A pottery kiln equipped with local exhaust ventilation is located in a small room in the basement. The exhaust ductwork however appears to be tied in with the general exhaust for the girl's restroom. Pottery kilns can produce carbon monoxide and sulfur dioxide, which can cause respiratory symptoms in exposed individuals (McCann, M., 1985). The configuration of the kiln exhaust presents the opportunity for kiln emissions to enter occupied areas if the general exhaust is not activated. The kiln should be vented directly outside, not connected to the general exhaust. In addition, the ductwork connecting the exhaust motor to the duct contains a number of turns (see Picture 15). Airflow is decreased roughly in half by every 90^{o} angle that exists in ductwork. This ductwork appears to contain over 320^{o} of angles. If the draw of fresh air by the exhaust fan were 100 percent, the angles of this ductwork would reduce that draw to less than 10 percent.

Accumulated chalk dust was noted in several classrooms. Many rooms contained dry erase boards. A few rooms had missing and/or dislodged ceiling tiles. Missing/dislodged ceiling tiles can provide a pathway for the movement of drafts, dusts and particulate matter between rooms and floors. Chalk dust and dry erase board particulates can be easily aerosolized and serve as eye and respiratory irritants. In addition, materials such as dry erase markers and dry erase board cleaners may contain VOCs (e.g., methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve) (Sanford, 1999), which can also be irritating to the eyes, nose and throat.

Also of note was the amount of materials stored inside classrooms. In classrooms throughout the school, items were observed on windowsills, tabletops, counters, bookcases and desks. The large number of items stored in classrooms provide a source for dusts to accumulate (see Picture 14). These items (e.g., papers, folders, boxes, etc.) also make it difficult for custodial staff to clean. Dust can be irritating to eyes, nose and respiratory tract. Items should be relocated and/or be cleaned periodically to avoid excessive dust build up.

Exposed fiberglass insulation was noted in wall holes in the speech/pathology room. Airborne fiberglass particles can serve as a skin and respiratory irritants to sensitive individuals.

Cleaning products and other chemicals were found in floor level cabinets and on counter tops in several classrooms (see Picture 16). Cleaning products contain chemicals (such as bleach or ammonia-related compounds), which can be irritating to the eyes, nose and throat. These items should be stored properly and out of the reach of students.

A number of wasp's nests were observed along the perimeter of the building (see Picture 17). Under current Massachusetts law that, effective November 1, 2001, the principles of integrated pest management (IPM) must be used to remove pests in state buildings and grounds (Mass Act, 2000).

Boiler room odors were detected in the basement hallway. An approximate 1-1 ½ inch space exists beneath the door. These spaces can serve as a means of egress for odors, fumes, dusts and vapors between the boiler room and the hallway.

Lastly, univents are normally equipped with filters that strain particulates from airflow. In order to decrease aerosolized particulates, disposable filters with an increased dust spot efficiency can be installed. The dust spot efficiency is the ability of a filter to remove particulates of a certain diameter from air passing through the filter. Filters that have been determined by ASHRAE to meet its standard for a dust spot efficiency of a minimum of 40 percent would be sufficient to reduce airborne particulates (Thornburg, D., 2000; MEHRC, 1997; ASHRAE, 1992). Note that increased filtration can reduce airflow produced by AHUs due to increased resistance (called pressure drop). Prior to any increase of filtration, each univent should be evaluated by a ventilation engineer to ascertain whether they can maintain function with more efficient filters. Univent filters were examined in classroom 2-O. Univents were equipped with two fibrous mesh filters in cardboard frames. Although filters appeared clean (see Picture 18), the left hand filter was cut to fit to fit into the rack. Cutting the filter can compromise the integrity of the filter and allow bypass around the frame.

Conclusions/Recommendations

The conditions noted at the MS raise a number of indoor air quality issues. The combination of the general building conditions, maintenance, design and the operation (or lack) of HVAC equipment, if considered individually, present conditions that could degrade indoor air quality. When combined, these conditions can serve to further negatively affect indoor air quality. Some of these conditions can be remedied by actions of building occupants. Other remediation efforts will require alteration to the building structure and equipment. For these reasons a two-phase approach is required, consisting of **short-term** measures to improve air quality and **long-term** measures that will require planning and resources to adequately address the overall indoor air quality concerns if the building is planned for longer term use.

The following short-term measures should be considered for implementation:

1. Remove and replace any mold contaminated/water damaged wall paneling, insulation, carpeting and ceiling tiles in the band room. This measure will remove actively growing mold colonies that may be present. Remove mold contaminated materials in a manner consistent with recommendations found in "Mold Remediation in Schools and Commercial Buildings" published by the US Environmental Protection Agency, Office of Air and Radiation, Indoor Environments Division, Washington, DC. EPA 402-K-01-001. March 2001. Copies of this document can be downloaded from the US EPA website at: http://www.epa.gov/iaq/molds/mold_remediation.html
2. Although cleaning has eliminated microbial growth from the carpet, further growth can be expected to occur once water moistens carpet in below grade areas. To avoid this occurrence, remove carpeting from basement areas where mold was detected prior to the cleaning. If visible mold and/or moisture are present, clean with an appropriate microbiological agent. Consider replacing basement carpets with an alternative sound attenuating floor tile.
3. Remove rubber baseboard coving during carpet removal and examine for fungal growth. If colonized with fungal growth, remove and replace up to six inches of GW along base of wall in accordance with recommendations found in "Mold Remediation in Schools and Commercial Buildings" published by the US Environmental Protection Agency.
4. Examine each univent for function. Survey classrooms for univent function to ascertain if an adequate air supply exists for each room. Consider consulting a heating, ventilation and

air conditioning (HVAC) engineer concerning the calibration of univent fresh air control dampers.

5. To maximize air exchange, the BEHA recommends that all ventilation systems that are operable throughout the building operate continuously during periods of school occupancy independent of thermostat control. To increase airflow in classrooms, set univent controls to “high”. Set univent thermostats to the fan “on” position to operate the ventilation system continuously during the school day.
6. Once both the fresh air supply and exhaust ventilation are functioning, the systems should be balanced by a ventilation engineering firm.
7. If original mechanical ventilation systems are not fully restored in the original building, ensure that abandoned exhaust and supply vents are properly sealed to eliminate pathways for movement of odors and particulates into occupied areas. This includes all classroom vents as well as openings on the roof and basement ventilation shafts.
8. Supplement airflow in classrooms by using openable windows to control for comfort. Care should be taken to ensure windows are properly closed at night and weekends to avoid the freezing of pipes and potential flooding.
9. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).

10. Replace any remaining water-stained ceiling tiles and wall plaster. Examine the area above and around these areas for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial.

11. Move plants away from univents in classrooms. Avoid over-watering and examine drip pans periodically for mold growth. Disinfect with an appropriate antimicrobial where necessary.

12. Seal areas around sinks to prevent water-damage to the interior of cabinets and adjacent wallboard. Inspect adjacent areas for water-damage and mold/mildew growth, repair/replace as necessary. Disinfect areas of microbial growth with an appropriate antimicrobial as needed.

13. Remove plant growing against the exterior wall/foundation of the building to prevent water penetration.

14. Replace missing ceiling tiles and fill utility holes in classrooms (e.g. around radiator pipes), to prevent the egress of odors, dust and particulate matter between areas.

15. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.

16. Clean chalkboards and dry erase board trays regularly to avoid the build-up of particulates.

17. Seal holes in speech/pathology room to avoid the aerosolization of fiberglass fibers.

18. Clean/change filters for dehumidifiers and air-handling equipment as per the manufacturer's instructions or more frequently if needed. Vacuum interior of units prior to activation to prevent the aerosolization of dirt, dust and particulates. Ensure filters fit flush in their racks with no spaces in between allowing bypass of unfiltered air into the unit.

19. Consider developing a written notification system for building occupants to report indoor air quality issues/problems. Have these concerns relayed to the maintenance department/ building management in a manner to allow for a timely remediation of the problem.
20. Store cleaning products properly and out of reach of students. Refrain from using strong scented (e.g. air fresheners) and/or VOC-containing materials.
21. Discontinue use of kiln until ventilation is reconfigured to exhaust directly outdoors.
22. Remove wasp's nests from perimeter of the building in a manner as to not introduce insects and/or pesticides into the building.
23. Consider replacing boiler room door or seal around door with weather-stripping material to prevent the egress of boiler room/fuel odors into occupied areas.
24. Examine the feasibility of increasing HVAC filter efficiency. Ensure that installed filters are of a proper size and installed in a manner to eliminate particle bypass of the filter. Note that prior to any increase of filtration, each unit should be evaluated by a ventilation engineer as to whether they can maintain function with more efficient filters.

The following **long-term measures** should be considered:

1. Based on the age, physical deterioration and availability of parts for ventilation components, the BEHA strongly recommends that an HVAC engineering firm fully evaluate the ventilation system, if longer term use is planned.
2. Examine the feasibility of providing mechanical supply and exhaust ventilation in the original building. Determine if existing airshafts, vents, ductwork, etc. can be retrofitted for (modern) mechanical ventilation.

3. Thermostat settings throughout the school should be evaluated. Thermostats should be set at temperatures to maintain comfort for building occupants.

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Picture 1

Ceiling-Mounted Univent in Classroom 2-O

Picture 2

Univent Fresh Air Intake

Picture 3

Wall-Mounted Exhaust Vent in Basement Classroom

Picture 4

Abandoned Classroom Supply Vent

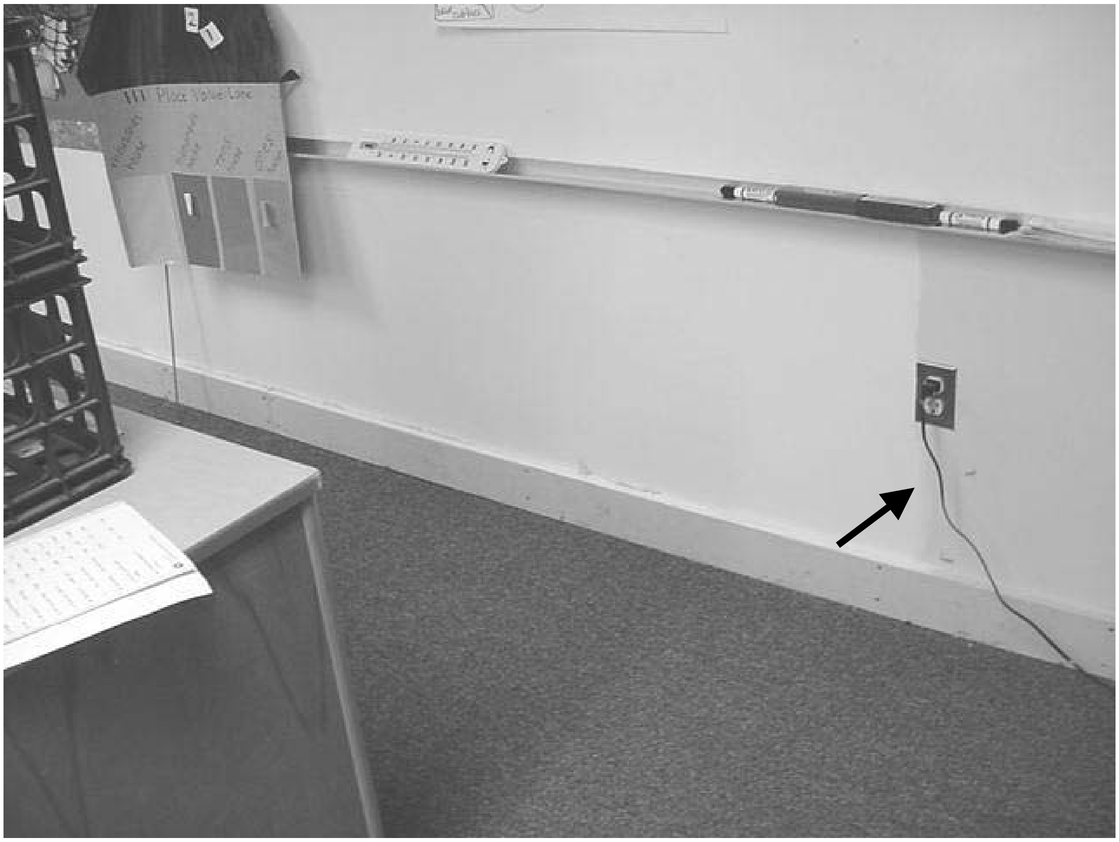
Picture 5

Abandoned Classroom Exhaust Vent

Picture 6

Louvered Chimney Cap, Note Melted Snow Due to Escaping Classroom Heat

Picture 7



Dividing Wall between Basement Classrooms 2-O & 2-M, Note Lined Delineating New Section of GW

Picture 8

One of Several Dehumidifiers in the Basement Band Room Containing Standing Water

Picture 9

Light Penetration around Basement Classroom Exterior Door

Picture 10

Carpeting Installed on Stairs near Basement Exterior Door, Note Water Damage along Bottom of Wooden Door

Picture 11

Plant in Standing Water in Classroom

Picture 12

Classroom Aquarium Green With Microbial Growth

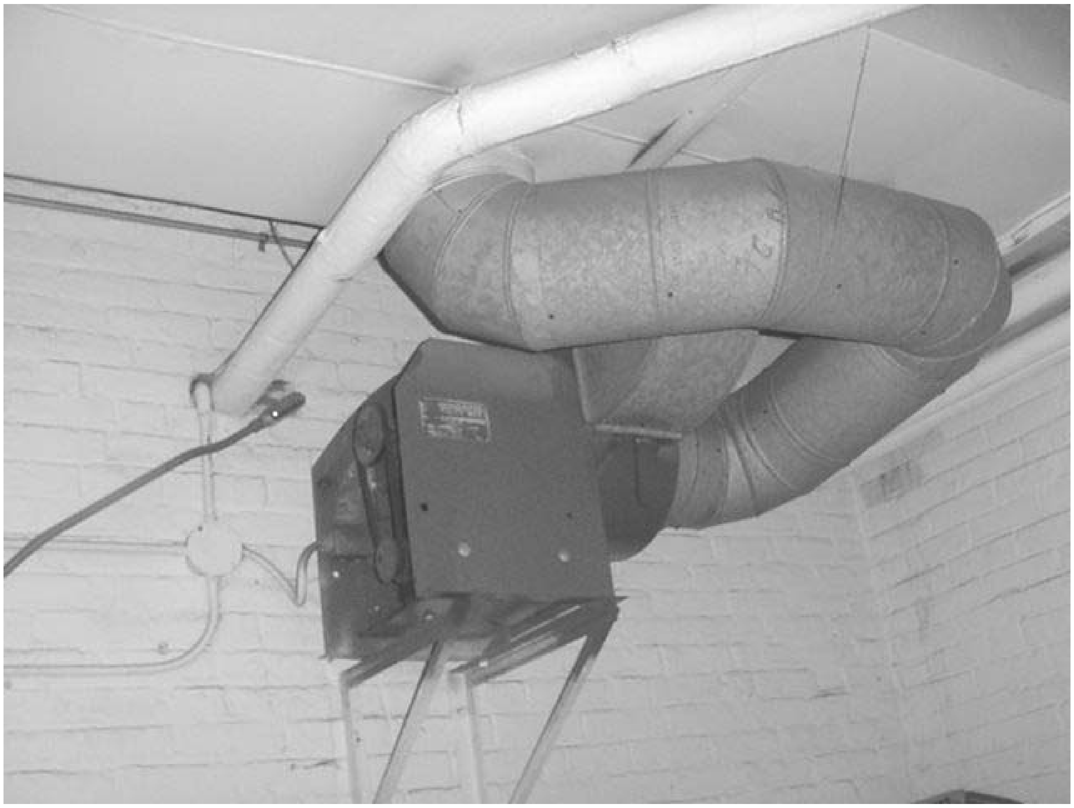
Picture 13

Trees/Roots Growing against the Building

Picture 14

Accumulated Dust on Radio in Classroom

Picture 15



Basement Kiln Vent, Note Configuration of Ductwork

Picture 16

Spray Bottle of Degreaser in Classroom

Picture 17

Wasp's Nests along Perimeter of Building (Side Door Parking Lot)

Picture 18

Univent Filters in Classroom 2-M

Table 1
Beverly, McKay Elementary School, December 31, 2002
Testing Results

Classroom Number	Carbon Dioxide ppm	Temp (^{o} F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Measured Wallboard Moisture Concentration (%)	Comments
Background (Outside)	368	56	45			**Intake**	**Exhaust**		Cold, overcast drizzle
2-O	468	68	32	0	Y	Yes	Yes	0.0	Moisture readings taken on South wall at 6", 1' and 2' (right, center and left) on replaced sheet rock wall, univent-off-filter clean, exhaust-on, no odors or visible water damage/mold growth on ceilings, walls or carpet
2-O								0.0	Moisture readings taken on West wall at 6", 1' and 2' (right, center and left)
2-M	475	69	29	0	Yes	Yes	Yes	0.0	Moisture readings taken on North wall at 6", 1' and 2' (right, center and left) opposite replaced sheet rock wall in 0-M, no odors or visible water damage/mold growth on ceilings, walls or carpet
2-M									Moisture Readings taken on West wall at 6", 1' and

Table 2
Beverly, McKay Elementary School, December 31, 2002
Testing Results

Classroom Number	Carbon Dioxide ppm	Temp (^{o} F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Measured Wallboard Moisture Concentration (%)	Comments
									2’ (right, center and left)
Adjustment Councilor	433	69	29	0	Yes	Yes (passive door vent)	Yes (2)	0.0	Moisture readings taken on North/South/East and West walls at 6”, 1’ and 2’ (right, center and left),
2	502	66	27		Yes	No	No	0.0	Moisture readings taken on North/South/East and West walls at 6”, 1’ and 2’ (right, center and left), Abandoned gravity ventilation system
1	482	67	31	0	Yes	No	No	0.0	Moisture readings taken on North/South/East and West walls at 6”, 1” and 2” (right, center and left), Abandoned gravity ventilation system
Band Room	495	69	31	0	Yes	No	No	0.0	Moisture readings taken on North/South/East and West walls at 6”, 1’ and 2’ (right, center and left), Dehumidifiers with standing water, musty odors, WD ceiling tiles

TABLE 3

Indoor Air Test Results –Beverly McKay Elementary School – January 7, 2003

Location	Carbon Dioxide *ppm	Temp °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
(Background) Outside	381	47	18					Clear, cold and sunny Wasps' nests along perimeter of building
Room 2	1082	69	34	16	Y	N	N	
Room 4	1100	72	34	21	Y	N	N	Exhaust sealed
Bathroom	652	71	27	0	Y	N	N	
Adjust. Councilor	806	71	25	0	N	Y	Y	Exhaust vents off
Room 2 M	828	71	23	17	Y	Y	Y	Window and door open UV – cycling, deb, exhaust on
Room 2 O	807	71	23	18	Y	Y	Y	Door open, UV – cycling
Speech & Path.	862	22	25	1	N	N	N	Holes in wall – fiberglass insulation
Kiln Room						N	Y	Exhaust vent appears to be tapped into R vent
Basement Hallway								Space under boiler room door
Room 15	1038	69	28	17	Y	N	N	Water stains on exterior wood door

*** ppm = parts per million parts of air**
UV = univent

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred 600 - 800 ppm = acceptable > 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 4

Indoor Air Test Results –Beverly McKay Elementary School – January 7, 2003

Location	Carbon Dioxide *ppm	Temp °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Room 12	1453	72	31	22	Y	N	N	
Room 7	1336	73	29	22	Y	N	N	Chalk dust
Room 11	1200	72	28	15	Y	N	N	Tennis balls-chair legs Door open
Room 10	1233	72	28	12	Y	N	N	Tennis balls-chair legs Plants
Room 9	1080	72	27	15	Y	N	N	Plants Window open
Room 5	1448	71	29	23	Y	N	N	Wall panel peeling back
Room 6B	1383	71	28	18	Y	N	N	
Room 6A	1043	71	26	14	Y	N	N	Plants Window open
Principal's Office	871	70	24	3	Y	N	N	
Reception	923	70	20	2	Y	N	N	

*** ppm = parts per million parts of air**

UV = univent

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%